Brief Response 3D

References:

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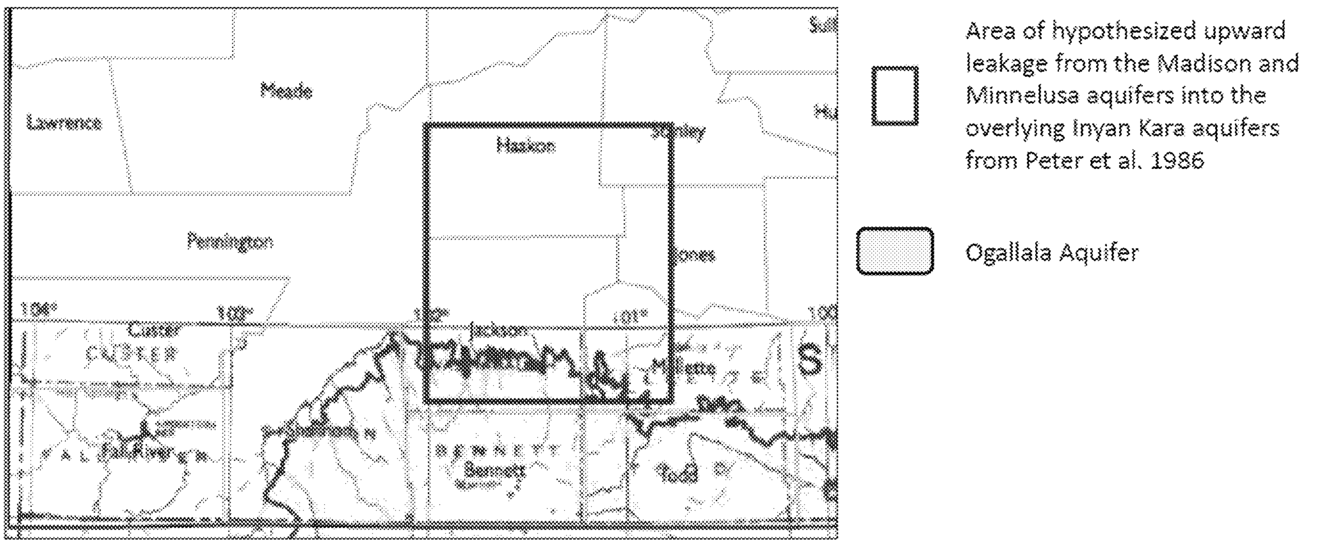
Strobel, M.L., Galloway, J.M., Hamade, G.R., and Jarrell, G.J., 2000, Potentiometric Surface of the Minnelusa Aquifer in the Black Hills Area, South Dakota, USGS Hydrologic Investigations Atlas HA-745-C

Response:
The EPA UIC Class III Area Permit requires the Permittee to demonstrate that the ISR wellfield closure will not result in ISR contaminants crossing the aquifer exemption boundary within the Dewey-Burdock Project Site. Therefore, no ISR contaminants will impact any downgradient portions of the Inyan Kara aquifer.

Groundwater Pathways and Aquifer Connections
The EPA investigated potential groundwater pathways between the injection zone aquifers at the Dewey-Burdock Project Site and aquifers at the Pine Ridge and Cheyenne River Reservations by reviewing publications that discussed possible aquifer interconnections, including upward groundwater flow from the underlying Madison and Minnelusa aquifers into the Inyan Kara aquifers. The Inyan Kara aquifers occur at depth at the Pine Ridge Reservation and at the Cheyenne River Reservation. Based on review of the areas where this type of aquifer interaction is thought to occur is to the east of the Black Hills where the Inyan Kara aquifers are located a depth below the ground surface and overlain by confining zones. Figure C shows one such area hypothesized by Peter et al., 1986 in relation to where the Oglalla Aquifer occurs in South Dakota. Based on review of geologic formation depths from USGS publications, from oil and gas test well logs and water well logs and the Inyan Kara potentiometric surface elevation in these areas, the EPA concludes that the thickness of confining zones between the Inyan Kara and the overlying Arikaree and Ogallala aquifers prevents Inyan Kara groundwater from flowing into the Arikaree and Ogallala aquifers.



Bredehoeft, et al., 1983, *Regional Flow in the Dakota Aquifer: A Study of the Role of Confining Layers*, USGS Water-Supply Paper 2237 developed flow models to simulate flow in the Dakota aquifers and simulate leakage through confining zones in South Dakota. In this paper, the Dakota aquifers include the Inyan Kara aquifers and the Newcastle sandstone that merge as the Skull Creek confining zone pinches out in central South Dakota. The Newcastle Sandstone is part of the Graneros Group as described in the Class III Permit Application, however, the Newcastle Sandstone is not present at the Dewey-Burdock

Project Site. In this report, the Minnelusa is included as part of the Madison Group aquifer system. Figure F shows a cross section that demonstrates how the Skull Creek confining zone pinches out and the Inyan Kara aquifers and the Newcastle Sandston merge to form the Dakota Aquifers. The Cretaceous confining zone includes the Mowry Shale and the Bell Fourche Shale of the Graneros Group, plus the Carlile Shale and the Pierre Shale.

The UIC Class V Area Permit allows injection into portions of the Minnelusa aquifer that do not meet the definition of USDW. The EPA investigated groundwater flow directions in the Minnelusa aquifer relative to the Pine Ridge and Cheyenne River Reservations. Figure H is a groundwater flow direction map from Figure 17 Driscoll at al., 2002, *Hydrology of the Black Hills Area, South Dakota*, Water-Resources Investigations Report 02-4094. This map shows the direction of groundwater flow in the Minnelusa aquifer from its recharge area in the Black Hills to a discharge area identified in this paper. As shown in the map in Figure H, the authors hypothesize that the Minnelusa aquifer groundwater flow from the Dewey-Burdock site eventually crosses the northwestern portions of the Pine Ridge Reservation.

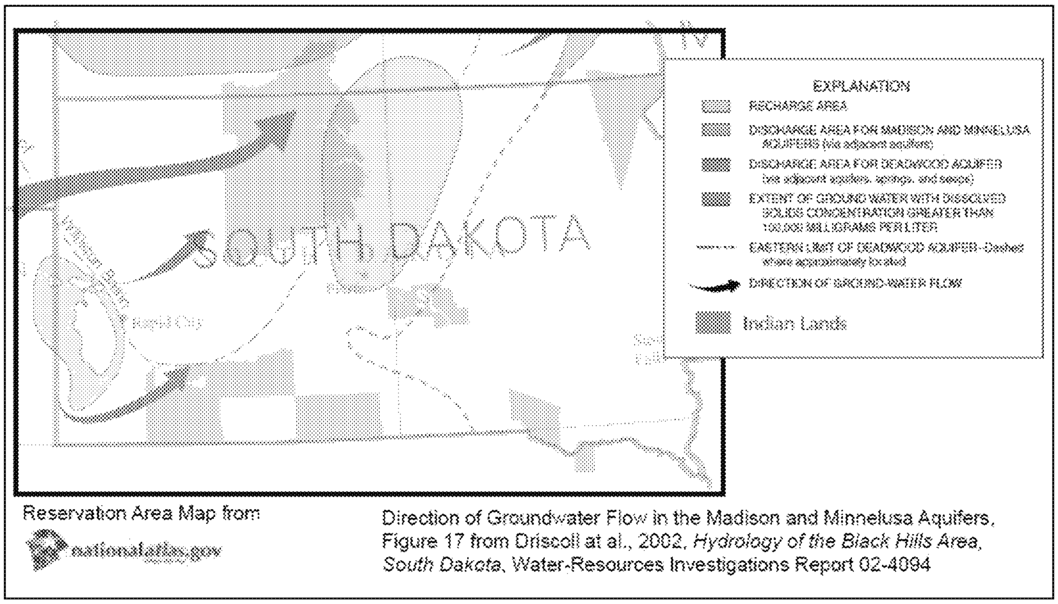


Figure D. Minnelusa aquifer groundwater flow direction map from Figure 17 Driscoll at al., 2002

The EPA examined oil and gas test wells located near this area to determine the depth of the Minnelusa aquifer in the northwest portion of the Pine Ridge Reservation and found the top of the Minnelusa aquifer is more than 3,800 feet below ground surface in this area. Springs emanating from or passing through the Minnelusa aquifer occur where the top of the Minnelusa aquifer occurs closer to the ground surface. For example, at the springs shown in Figure E, from Figure 8 of Naus et al. 2001, the top of the Minnelusa is approximately 200 or less feet below ground surface, based on nearby private well logs.

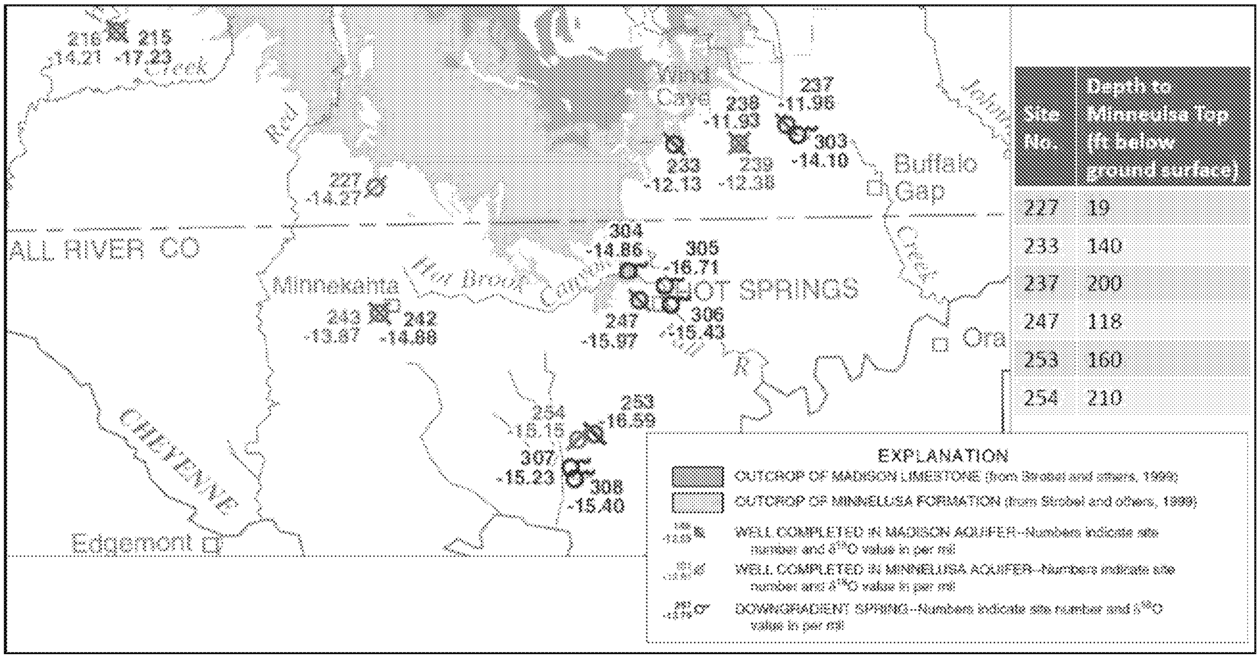


Figure E. Locations of springs emanating from or passing through the Minnelusa aquifer, from Figure 8 of Naus et al., 2001.

The EPA has investigated the area identified as a discharge area for the Minnelusa and Madison aquifers in the area shown in Figure D that coincides with the eastern portion of the Cheyenne River Reservation. The discharge area represents the area where Madison and Minnelusa groundwater is moving upward into the Inyan Kara aquifers (Downey and Dinwiddie, 1988). Based on oil and gas test well logs the EPA reviewed, the depth to the top of the Minnelusa aquifer in the area of discharge is approximately 3,000 feet below ground surface and the top of the Inyan Kara aquifer is approximately 2,000 feet below ground surface. According to Howells, 1979, the Pierre Shale is present at the surface of the eastern portion of the Cheyenne River Reservation. Most of the intervening geologic units between the top of the Inyan Kara, including the Pierre Shale, are confining units. Based on this information, the EPA concludes that neither the Minnelusa nor the Inyan Kara injection zones discharge to ground surface at the Cheyenne River Reservation. The EPA examined test oil and gas well logs and found that along the eastern edge of the Cheyenne River Reservation the top of the Inyan Kara ranges from 1500 in the southeast to 2800 in the northeast. The top of the Inyan Kara deepens from south to north as it descends further into the Williston Basin.

Surface Water Pathways

The Dewey-Burdock site is located in the Cheyenne River basin. The Class III Area Permit requirements are designed to maintain vertical containment of ISR injection interval fluids, preventing them from reaching the ground surface and impacting the Cheyenne River through corrective action of existing breaching in confining zones and demonstration of mechanical integrity of injection, recovery and monitoring wells at Class III ISR wellfields to prevent breaches in confining zones from improper well construction.

The Class III Area Permit requires the Permittee to identify and perform corrective action on any breaches in confining zones in Class III ISR wellfield areas, including improperly plugged historic exploration boreholes and private wells, that could serve as pathways for Class III injection zone fluids to reach the ground surface. If a confining zone breach is not able to be located or repaired, the Permittee must demonstrate that Class III injection zone fluids are contained through operational controls and monitoring. These requirements are found in Part III of the Class III Area Permit and discussed in Section 6.0 of the Class III Fact Sheet.

Part VII, Section B of the Class III Area Permit requires the Permittee to demonstrate initial mechanical integrity of all injection and production wells and maintain mechanical integrity through the life of the well. Part II, Section D.4.e. of the Class III Area Permit requires demonstration of initial mechanical integrity monitoring wells. Initial mechanical integrity is demonstrated through evaluation of well cementing records.

The Class III Area Permit requires horizontal control of injection interval fluids within each wellfield. Horizontal control is maintained by injecting a smaller volume of water into the wellfield than is being removed by the production wells. Horizontal control is demonstrated through excursion monitoring as discussed in Section 12.5 of the Class III Fact Sheet and by continuous monitoring of the injectate flow volume and the recovery flow volume for each wellfield as required in Part IX, Section B, Table 14.A of the Class III Area Permit.

As shown in Figure C is a screen shot of [HYPERLINK "https://sdbit.maps.arcgis.com/apps/MapSeries/index.html?appid=cc5c9f4281db41ed93d324e218e01478"] (Impairment Status tab). The green-dash lines are river drainage basin boundaries. The enlarged portion of the map shows that Wounded Knee Creek is located in the White River drainage basin. Because the Dewey-Burdock site is located in the Cheyenne River basin, there is no surface water connection between the Dewey-Burdock Project Site and the White River drainage basin. Based on the geography of the White River drainage basin, it does not receive surface water originating from the Black Hills.

Based on the protective requirements of the Class III Area Permits, the EPA has concluded there will be no impacts to the Cheyenne River and downstream communities from the Class III injection activities.

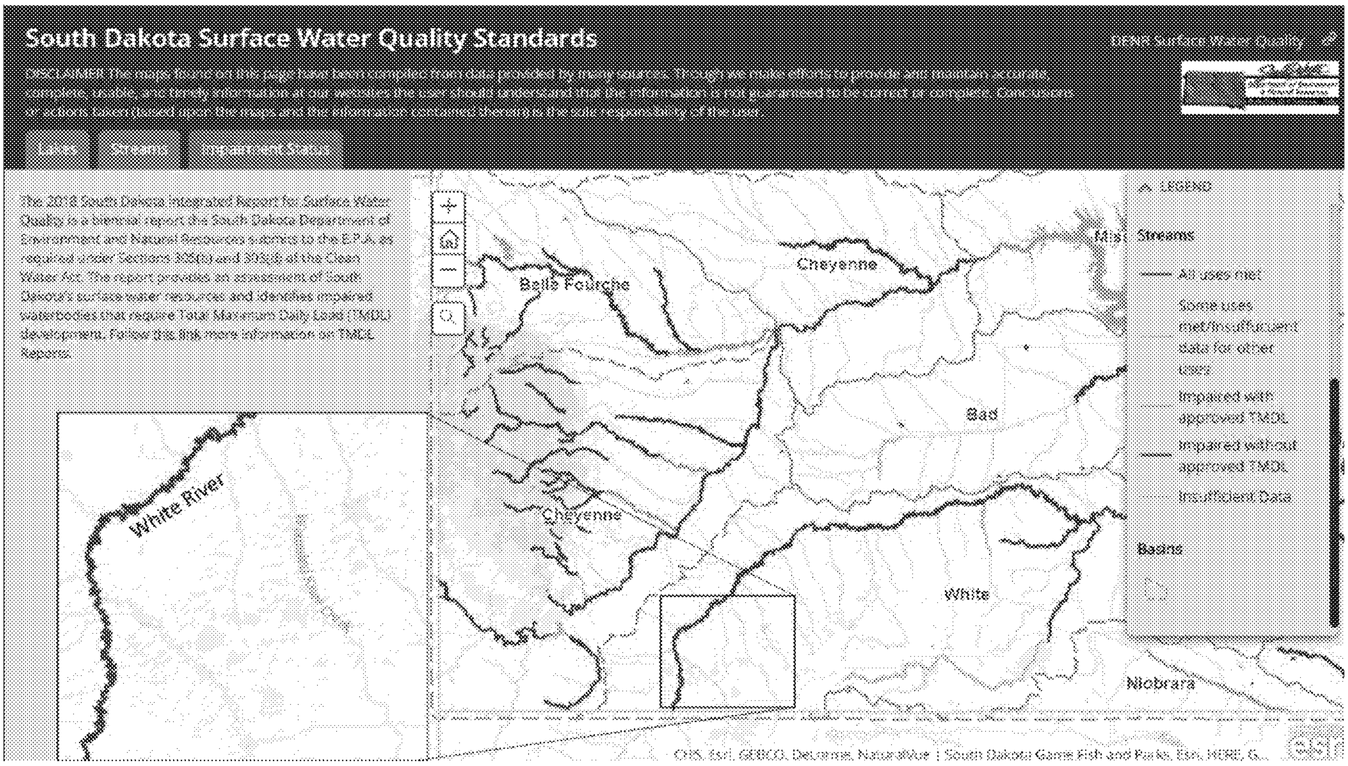


Figure C. Screenshot of the South Dakota Surface Water Quality Standards map (Impairment Status tab) showing drainage basin boundaries as green-dashed lines.